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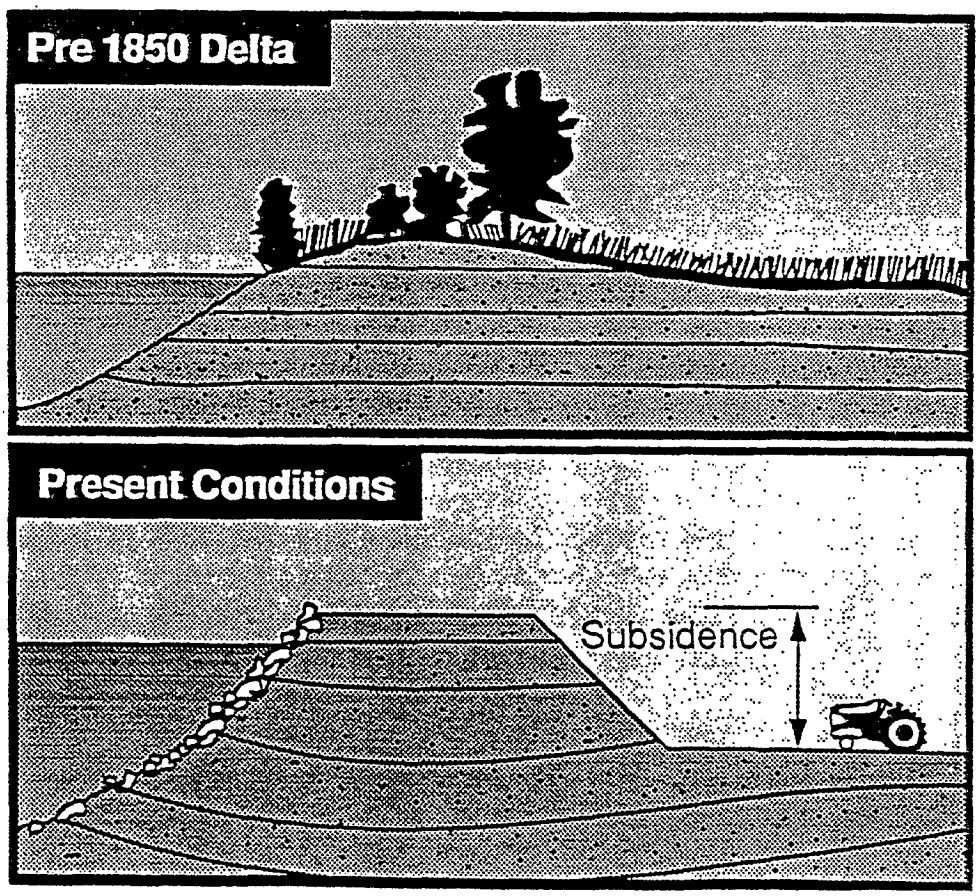
DELTA LEVEES AND CHANNELS



BAY-DELTA OVERSIGHT COUNCIL
LEVEE AND CHANNEL MANAGEMENT
TECHNICAL ADVISORY COMMITTEE

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BAY-DELTA OVERSIGHT COUNCIL

LEVEE AND CHANNEL MANAGEMENT TECHNICAL ADVISORY COMMITTEE

REPORT TO BDOC

October 1994

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

The Delta Levees and Channel Management Technical Advisory Committee (TAC) was created to assist the Water Policy council and the Bay-Delta Oversight Council (BDOC) in developing a comprehensive program that will improve the levees and channels within the Sacramento-San Joaquin Delta. BDOC established a set of objectives for the Delta levees and channels TAC which guided our efforts.

During the past 5 months, the TAC has met 16 times with good participation from its 13 well-qualified members. The TAC has determined that there are many problems with the current system for maintaining levees and channels. It was the consensus of the TAC that levees, channels, and habitat could be improved and maintained to reasonable standards if there was sufficient funding. The principal problems involved funding and regulatory issues rather than technological ones. In the past, the ability to maintain and improve the levee and channel system has been beyond the financial resources of the individual island reclamation districts. However, the beneficiaries of the levee and channel system extend beyond the mostly agricultural interests on the individual islands.

Consistent with the direction that "all options are on the table," the TAC developed one unconstrained vision of the future. This vision consisted of a regional plan of protection for maintaining levees and channels in the Delta. The plan of protection would require a management agency which would collect funds from all of the beneficiaries, prioritize needs, and allocate funds to improve and maintain a Delta levee and channel system.

There were attempts to develop specific proposals for every levee in the Delta. However, this was an impossible charge for the Levees and Channels TAC because levees are not in themselves a specific benefit. Levees serve to provide flood control to protect specific benefits (e.g. farm land, riparian habitat, water quality, etc...) or to provide habitat themselves. Without first identifying the needs and locations of benefits which need to be either protected or provided for, and prioritizing these benefits, specific proposals for levee and channel improvements could not be fully developed. Another problem was that levee materials, foundation conditions, geometry's, and channel configurations are extremely variable within the Delta. Levee and channel improvements need to be developed on a site specific basis and the information necessary to do this is not currently available.

In light of the above constraints and the vision established for the future, the TAC decided that it could best meet the objectives established by the Council by outlining different types of management plans that could implement a plan of protection for

the Delta. The TAC focused on developing the tools necessary to make the plan of protection vision a reality. These tools include: 1) basic tenets and assumptions; 2) criteria for the evaluation of alternative plans; 3) examples of levee and channel improvements; and 4) a management framework with options for each management element in the plan of protection.

Besides significant internal discussion, the TAC has used a number of other techniques to aid in the development of these products. The TAC formed three subcommittees — levee design, levee habitat and recreation, and beneficiaries and cost sharing. We also held a joint meeting with the wildlife TAC to better understand their concerns. Furthermore, presentations on various Delta issues were made to the TAC.

The intent of this report is to provide a foundation from which future efforts can build a detailed and comprehensive plan of protection for the Delta's levees and channels. Given the diverse talent which was assembled for this BDOC TAC, this initial scoping should greatly aid in the focusing of future long term planning.

OBJECTIVES, GOALS, BASIC TENETS AND ASSUMPTIONS

BDOC directed the TAC's work by providing general and specific objectives. These objectives are:

GENERAL OBJECTIVE

Improve and maintain a Delta levee and channel system to sustain associated multiple uses.

SPECIFIC OBJECTIVES

- Improve the condition and adequacy of Delta levees and channels through physical modification and management approaches that are flexible, effective, economical and environmentally sound.

  Council Note: Measures to reduce flood stages as well as potential changes in levee and channel configuration will be considered.

- Decrease the potential for catastrophic effects from earthquake damage to a Delta levee and channel system.

  Council Note: Achievement of this objective may include physical measures as well as contingency plans for restoration.

- Develop a unified approach with federal, State, regional, and local agencies to manage the multitude of issues that affect a Delta Levee and channel system.

  Council Note: Unified planning will address subsidence, habitat values, managing flood stages, etc.

The TAC used BDOC's objectives to create goals and basic tenets and assumptions to narrow the TAC's focus even farther. These goals basic tenets and assumptions are:

GOALS

- A framework for a 50 year plan of protection for the levees and channels in the Sacramento-San Joaquin Delta, including a basis for equitable cost sharing needs to be developed.

- Criteria to evaluate alternative plans of protection for the levees and channels in the Sacramento-San Joaquin Delta need to be developed.

BASIC TENETS AND ASSUMPTIONS

1. Land reclamation for agriculture is generally considered to have been the original purpose for constructing the existing Delta levee and channel system. Currently, there are multiple uses, benefits, and beneficiaries associated with maintaining levees and channels. These include but are not limited to water transfer, water quality, agriculture, local culture, aquatic and land habitat, utilities, urban areas, navigation, transportation, and recreation.

2. Regardless of current or future water transfer facilities and/ or operations, at least a portion of the existing Delta levee and channel system will need to be maintained.

3. A future seismic or flood event could extensively damage the existing Delta levee and channel system. Levees on the western edge of the Delta are at significant risk for future earthquake-induced failure distress and/or failure. Widespread failure would have devastating results on multiple islands, associated multiple uses, Delta water quality, and other beneficiaries.

4. Due to on-going subsidence, erosion, and other factors, most Delta levees require continued maintenance and, in places, remediation in order to just maintain marginal stability.

5. It is difficult to assure that levees will be stable and/or maintained for the future with existing funding levels, regulatory processes, and competing interests.

6. Levee improvements should be designed for site specific conditions. To maximize resources, there can be no rigid design templates for either levee stability or environmental enhancement.

EVALUATION CRITERIA

In order to develop a method of evaluating the various options' compatibility with Delta levees and channels, evaluation criteria was identified. The evaluation criteria have been divided into the following four main categories: (1) levee criteria, (2) channel criteria, (3) beneficial use criteria, and (4) Management Criteria. Each of the criteria issues has been given a weighting factor depending on its degree of importance. A weighting factor of 5 indicates extreme importance and a weighting factor of 0 indicates no significant importance. This weighting factor is then multiplied by the score (described below) to determine the total value for each parameter. Figure 3-1 was created to aid in the evaluation process. The options will be determined as more information becomes available.

LEVEE CRITERIA

Criteria - Does the proposal address interior island subsidence?

Scoring - +2 = Greatly reduces the current level of subsidence.
+1 = Slightly reduces the current level of subsidence
0 = Continues the current level of subsidence
-1 = Slightly increases subsidence
-2 = Greatly increases subsidence

Criteria - Does the proposal improve levee integrity? (e.g. freeboard, stability, seepage, settlement)

Scoring - +2 = Greatly improves integrity
+1 = Slightly improves integrity
0 = Maintains current level of integrity
-1 = Slightly reduces integrity
-2 = Greatly reduces integrity

Criteria - Does the proposal improve earthquake resistance?

Scoring - +2 = Greatly improves resistance
+1 = Slightly improves resistance
0 = Maintains the current level of resistance
-1 = Slightly decreases resistance
-2 = Greatly decreases resistance

Criteria - Does the proposal facilitate routine maintenance and inspection?

Scoring - +2 = Greatly improves ability to maintain and inspect
+1 = Slightly improves ability to maintain and inspect
0 = No change in ability to maintain and inspect
-1 = Slightly reduces the ability to maintain and inspect
-2 = Greatly reduces the ability to maintain and inspect

Criteria - Does the proposal provide adequate level of flood protection?

Scoring - +2 = Greatly improves flood protection
+1 = Slightly improves flood protection
0 = Maintains current level of flood protection
-1 = Slightly reduces flood protection
-2 = Greatly reduces flood protection

Criteria - Does the proposal address waterside erosion?

Scoring - +2 = Greatly decreases waterside erosion
+1 = Slightly decreases waterside erosion
0 = No change in current waterside erosion
-1 = Slightly increases waterside erosion
-2 = Greatly increases waterside erosion

Criteria - Is the proposal realistic/feasible?

Scoring - +2 = Highly feasible
+1 = Moderate feasibility
0 = Average feasibility
-1 = Low feasibility
-2 = Remote chance of successful implementation

Criteria - Does the proposal identify reliable and economical sources of borrow material for levee improvements?

Scoring - +2 = Greatly increases the amount of borrow material currently available
+1 = Increases the amount of borrow material currently available
0 = Maintains existing supply of borrow material
-1 = Proposal provides less borrow material than currently available
-2 = Proposal provides much less borrow material than currently available

CHANNEL CRITERIA

Criteria - Does the proposal affect channel capacity?

Scoring - +2 = Greatly increases capacity
+1 = Slightly increases capacity
0 = Maintains existing capacity
-1 = Slightly reduces capacity
-2 = Greatly reduces capacity

Criteria - Does the proposal affect navigation in the channel?

Scoring - +2 = Greatly improves navigation
+1 = Slightly improves navigation
0 = Maintains existing navigation
-1 = Slightly hinders navigation
-2 = Significantly hinders navigation

Criteria - Does the proposal affect dredging in the channel?

Scoring - +2 = Greatly reduces the existing limitations on dredging
+1 = Slightly reduces the existing limitations on dredging
0 = Maintains the existing limitations on dredging
-1 = Slightly increases the existing limitations on dredging
-2 = Greatly increases the existing limitations on dredging

Beneficial Use Criteria

Criteria - Does the proposal identify and preserve a Delta levee and channel system?

Scoring - +2 = Greatly improves existing or equivalent system
+1 = Slightly improves existing or equivalent system
0 = Maintains existing levee and channel system
-1 = Reduces existing system by 10%
-2 = Reduces existing system by 20%

Criteria - Does the proposal affect water transfer?

Scoring - +2 = Greatly improves the ability to transfer water
+1 = Slightly improves the ability to transfer water
0 = Maintains the existing ability to transfer water
-1 = Slightly reduces the ability to transfer water
-2 = Greatly reduces the ability to transfer water

Criteria - Does the proposal affect terrestrial habitat?

Scoring - +2 = Increase of over 20% of the habitat
+1 = Increase of 1 - 20% of the habitat
0 = Maintains existing habitat
-1 = Reduction of 1 - 20% of the habitat
-2 = Reduction of over 20% of the habitat

Criteria - Does the proposal affect aquatic habitat?

Scoring - +2 = Increase of over 20% of the habitat
+1 = Increase of 1 - 20% of the habitat
0 = Maintains existing habitat
-1 = Reduction of 1 - 20% of the habitat
-2 = Reduction of over 20% of the habitat

Criteria - Does the proposal affect land use on the island?

Scoring - 0 = Maintains existing land use
-1 = Slightly alters existing land use (10%)
-2 = Greatly alters existing land use

Criteria - Does the proposal affect local water supply?

Scoring - +2 = Greatly improves quality and quantity of local water supply
+1 = Slightly improves quality and quantity of local water supply
0 = No effect on local water supply
-1 = Slightly reduces the quality and quantity of local supply
-2 = Greatly reduces local water supply

Criteria - Does the proposal affect local culture?

Scoring - +2 = Greatly enhances local culture
+1 = Slightly enhances local culture
0 = No affect on local culture
-1 = Slightly reduces local culture
-2 = Greatly reduces local culture

Criteria - Does the proposal affect the economic stability of the region?

Scoring - +2 = Greatly improves the economic stability
+1 = Slightly improves the economic stability
0 = No effect on the economic stability
-1 = Slightly reduces the economic stability
-2 = Greatly reduces the economic stability

Criteria - Does the proposal affect recreation?

Scoring - +2 = Greatly increases recreational opportunities
+1 = Increases recreational opportunities
0 = Maintains current recreational opportunities
-1 = Slightly reduces recreational opportunities
-2 = Greatly reduces recreational opportunities

MANAGEMENT CRITERIA

Criteria - Does the proposal facilitate a unified regulatory approach?

Scoring - +2 = Timely approval of all regulatory permits
+1 = Some improvement over existing regulatory process
0 = Same as existing regulatory process
-1 = Regulatory process is slightly more cumbersome than existing process
-2 = Regulatory process is much more cumbersome than existing process

Criteria - Does the proposal describe funding mechanisms?

Scoring - +2 = Most of the required funding is described and available
+1 = Funding is easier to obtain than the existing mechanisms
0 = No change in funding mechanisms
-1 = Funding slightly harder to obtain than existing mechanisms
-2 = Funding mechanisms are either not described or cannot meet needs of proposal

Criteria - Does the proposal provide means for reclaiming the islands after flooding?

Scoring - +2 = Creates fund and plan to reclaim all critical Delta islands
+1 = Creates fund and plan to reclaim some of the critical Delta islands
0 = Maintains existing level of disaster assistance
-1 = Slightly reduces existing level of disaster assistance
-2 = Greatly reduces existing level of disaster assistance

Criteria - Does the proposal account for long term changes (climate, channel siltation, earthquake, flood)?

Scoring - +2 = Accounts for most long term changes
+1 = Accounts for some long term changes
0 = No change
-1 = Slightly increase Delta vulnerability to long term changes
-2 = Greatly increase Delta vulnerability to long term changes

CRITERIA		OPTIONS								
		Weight	Score	Total	Weight	Score	Total	Weight	Score	Total
Levee Criteria	Future Subsidence	4			4			4		
	Levee Integrity	5			5			5		
	Earthquake Resistance	4			4			4		
	Maintenance	4			4			4		
	Flood Control	5			5			5		
	Waterside Erosion	4			4			4		
	Feasibility	5			5			5		
	Borrow Material	3			3			3		
Channel Criteria	Channel Capacity	3			3			3		
	Navigation	3			3			3		
	Dredging	3			3			3		
Beneficial Use Criteria	Delta System	5			5			5		
	Water Transfers	4			4			4		
	Terrestrial Habitat	4			4			4		
	Aquatic Habitat	4			4			4		
	Land Use	2			2			2		
	Local Water Supply	2			2			2		
	Local Culture	2			2			2		
	Economic Stability	2			2			2		
	Recreation	2			2			2		
Management Criteria	Regulatory Approach	5			5			5		
	Funding	5			5			5		
	Reclaiming Islands	5			5			5		
	Long Term Changes	3			3			3		
GRAND SCORE										

Figure 3-1: Evaluation Criteria

LEVEE AND CHANNEL IMPROVEMENT EXAMPLES

The purpose of this section is to present a brief description of levee history in the Sacramento-San Joaquin Delta, to define basic elements in the levee and channel system, and to describe examples of different design options available for use in improving the Delta's flood control, environment, and recreational opportunities along levees and channels. These design options were envisioned as tools from which final levee plans will be developed once funding, environmental, land-use, and water supply alternatives have been defined.

LEVEE HISTORY

Levees were first constructed in the Sacramento-San Joaquin Delta during the late 1800s in order to reclaim marsh lands for agricultural use. Prior to reclamation, most of the central Delta area was composed of tule land with a surface elevation close to mean sea level. Most of the early levees in the Delta were constructed by Chinese laborers using hand shovels and wheelbarrows, and some were built using scrapers pulled by horses. In many areas, the pre-existing natural levees along rivers and sloughs were used to provide the foundation of the enlarged man-made levees. By the turn of the century, the sidedraft-clamshell dredge was in common use and allowed the construction of larger levee fills and the creation of new dredged channels through the Delta system.

The levees were generally constructed of non-select, uncompacted materials without either engineering design or good construction methods. The original man made levees were usually less than five feet high, but settlement of these levees and subsidence of the interior island soils has required the addition of fill to maintain protection against overtopping by flood waters. The interiors of many islands are now commonly 10 to 15 feet below sea level. Presently, some levee crowns are 25 feet higher than the interior of their respective islands. Figure 4-1 illustrates the development of Delta levees over time.

BASIC ELEMENTS OF DELTA LEVEES

There are now over 1,100 miles of levees protecting low lying islands and tracts in the Sacramento-San Joaquin Delta. As may be expected, there are wide ranges in levee size, geometry, and composition. The vast majority of levees are approximately 10 to 25 feet in height, have crown widths between 15 and 25 feet,

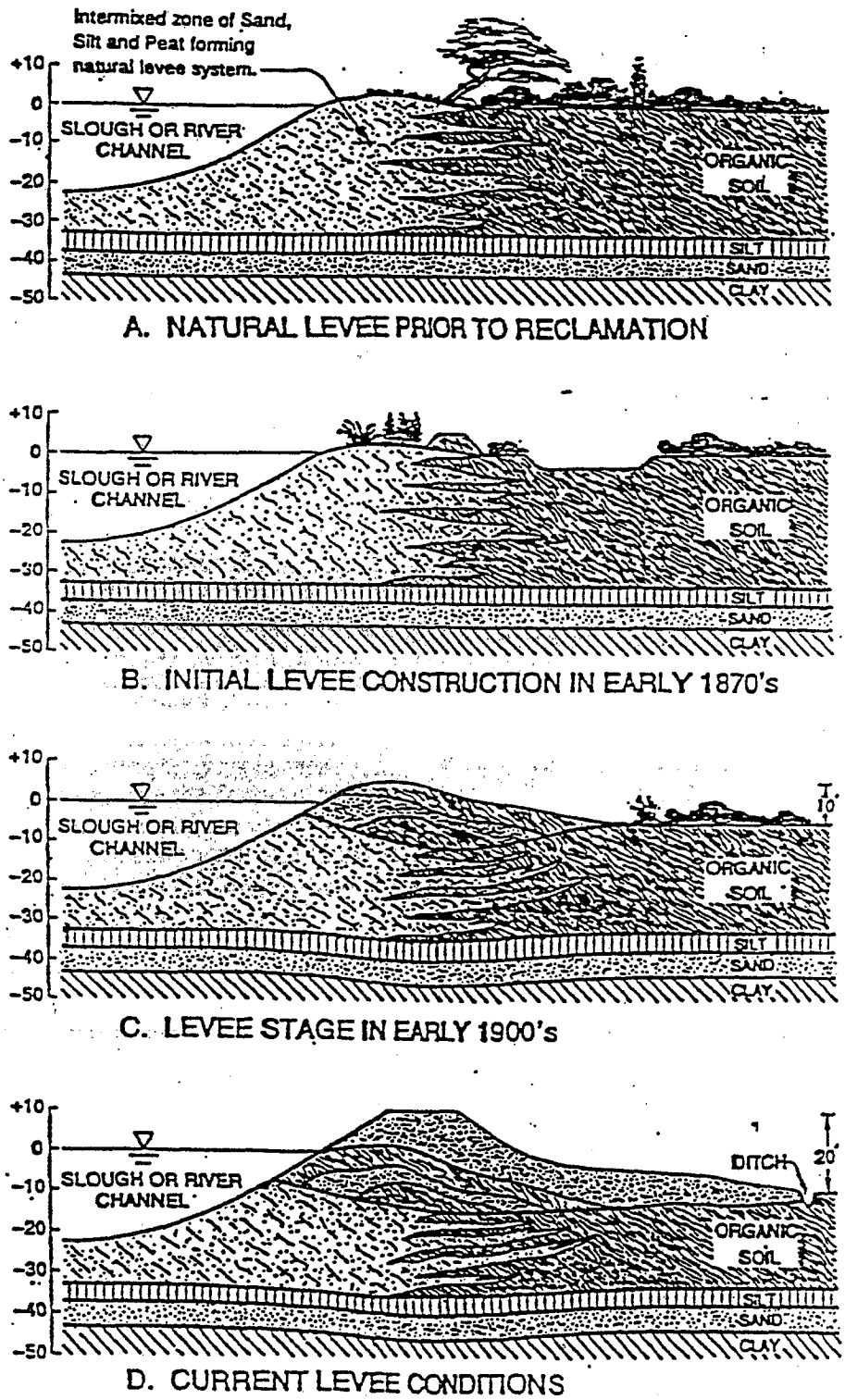


Figure 4-1: Development of Delta Levees (CDWR, 1992)

and crown elevations between 7 and 12 feet above mean sea level (National Vertical Geodetic Datum). Many levees in the Central and Western Delta have had berms or flattened levee slopes added to the landside portion to provide additional stability. Many levees also have seepage collection ditches running parallel to the levee to collect and control seepage coming through the levee and levee foundation. Figure 4-2 presents a schematic drawing identifying some of the basic elements in a typical Delta levee:

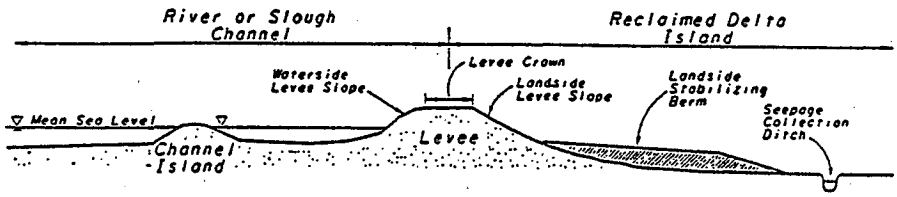


Figure 4-2: Basic Elements of Delta Levees

Modes of Levee Failure

Reclamation of the Delta islands and increasing recreational use of the Delta levees and channels has contributed to loss of both aquatic and riparian habitat. It is also well known that Delta levees are only marginally stable and require constant maintenance and repairs in order to provide flood protection. Since 1900, there have been approximately 150 island inundations principally caused by:

- Overtopping.
- Slope or foundation failure (slope instability).
- Internal erosion or piping.
- Levee collapse into large rodent burrows (beaver dens).
- Erosion caused by loss of waterside slope protection.
- Compromised levee performance due to encroaching structures.

Failures may be induced by either existing static loading, subsidence, flood events, and/or seismic events.

Levee Improvement Examples

Provided in the following six pages are tables illustrating seventeen examples for improving Delta levees. The examples include:

a. Increasing the size of levees to provide increased flood protection, structural stability, and waterside habitat.

b. Placing special filters or impermeable elements to control seepage and internal erosion.

c. Densifying the levees and foundations to reduce liquefaction potential and improve seismic stability.

d. Placing fill in the channel to provide waterside habitat.

e. Placing fill to provide recreational locations.

f. Modifying island land uses in order to control subsidence and provide increased riparian or wetland habitat.

g. Maintaining vegetation that would be compatible with maintaining the structural integrity of the levee.

The levee improvement examples are shown to illustrate the kinds of measures that are available for improving the structural integrity and benefits of Delta islands and channels. The examples are not intended to compete with each other. One example is not necissarily better than another. More than one of these types of improvement examples may be used along a levee reach protecting a Delta island. The application of these types of improvement examples must be done on a site specific basis using the information available to maximize the benefits with the available financial and site specific resources.

TABLE 4-1: EXAMPLES OF LI ; AND HABITAT IMPROVEMENTS

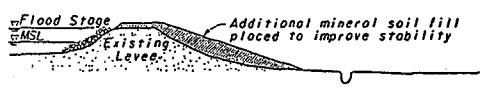
LEVEE IMPROVEMENT EXAMPLES	PURPOSE	ICABLE AREAS	POSITIVES	NEGATIVES
 A. Placement of Fill on Levee Crown and Landside Slope in Firm Mineral Soil Foundation Areas	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path.	dation areas, generally outer fringes of Delta l stream channels filled al soils.	a. Levee structural stability is improved. b. Levee improvements stay within general footprint of existing levee and drain ditch. c. Relatively easily maintained as a flood control levee. d. Provides small increase in seismic stability.	a. Requires import of mineral soil. b. Represents a significant cost. c. Provides no environmental enhancement. d. Provides no significant increase in seismic stability. e. Addition of fill may result in short-term instability and/or cracking if levee/foundation system is weak.
 B. Placement of Fill on Levee Crown and Landside Slope, Together with Landside Berm in Soft Foundation Areas	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation.	s of Delta, but applicable in areas t foundation material	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability.	a. Requires significant import of mineral soil. b. Represents a significant cost. c. Provides no environmental enhancement. d. Provides only slight increase in seismic stability. e. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. f. Seepage system may need to be modified. g. Infringes on inboard farm land or habitat areas.
 C. Placement of Fill on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Seepage Cutoff Wall (Slurry or Sheetpile Wall)	o Increases freeboard and flood protection. o Increases landside slope stability. o Significantly lengthens seepage path, stops concentrated seepage areas. o Placement of berm accounts for soft foundation.	he Delta where both lation materials and . concentrated. oblems exist.	a. Levee structural stability is improved. b. Provides significant improvement in control of seepage problems in levee. c. Relatively easily maintained as a flood control levee. d. May provide moderate improvement in seismic stability of levee if water levels inboard of cutoff wall are greatly reduced within levee (reduces amount of possible liquefaction).	a. Requires significant import of mineral soil. b. Placement of fill represents a significant cost. c. Construction of cutoff wall represents a major cost. d. Provides no environmental enhancement. e. Levee and foundation may still be unstable during earthquake loading. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Construction of cutoff wall may result in hydraulic fracturing and/or levee cracking if not carried out carefully. h. Lowered ground water inboard of wall may result in differential settlement and cracking. i. Seepage system may need to be modified.

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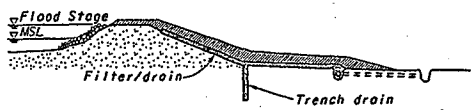
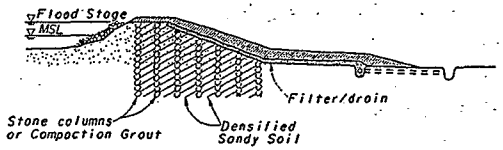
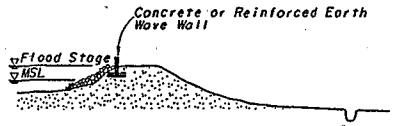
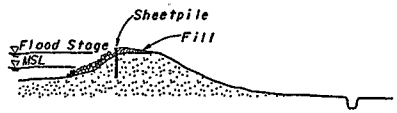
TABLE 4-1: EXAMPLES OF L[EVEE] AND HABITAT IMPROVEMENTS

LEVEE IMPROVEMENT EXAMPLES	PURPOSE	ICABLE AREAS	POSITIVES	NEGATIVES
 D. Placement of Fill on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Filter/Drain System on Landside Slope	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path, stabilizes concentrated leaks and prevents piping erosion. o Placement of berm accounts for soft foundation.	he Delta where both dation materials and , concentrated settlement and roblems exist.	a. Levee structural stability is improved. b. Provides significant improvement in control of seepage problems in levee. c. May prevent piping erosion associated with both flood events and moderate earthquake-induced settlement and cracking.	a. Requires significant import of mineral soil. b. Placement of fill represents a significant cost. c. Construction of filter/drain represents additional cost. d. Provides no environmental enhancement. e. Levee and foundation may still be unstable during earthquake loading. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Seepage system may need to be modified. h. Seepage and filter/drain system may need to be maintained. i. Infringes on inboard farm land or habitat areas.
 E. Placement of Fill on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Filter/Drain System on Landside Slope and Toe Drain	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path, stabilizes concentrated leaks and prevents piping erosion through both levee and foundation. o Placement of berm accounts for soft foundation.	he Delta where both ation materials and concentrated settlement and oblems exist. suited where ion problems levee foundation.	a. Levee structural stability is improved. b. Provides significant improvement in control of seepage problems in levee and foundation. c. May prevent piping erosion associated with both flood events and moderate earth quake-induced settlement and cracking.	a. Requires significant import of mineral soil. b. Placement of fill represents a significant cost. c. Construction of filter/drain on both slope and in trench represents additional cost. d. Provides no environmental enhancement. e. Levee and foundation may still be unstable during earthquake loading. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Construction of drain trench may cause levee distress or seepage problems if not carried out carefully. h. Seepage system may need to be modified. i. Seepage and filter/drain system may need to be maintained. j. Infringes on inboard farm land or habitat areas.

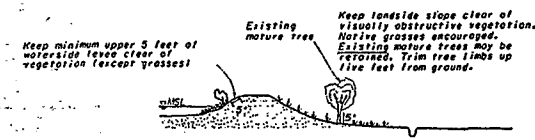
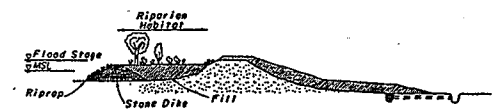
C-070619

TABLE 4-1: EXAMPLES OF LEV ND HABITAT IMPROVEMENTS

LEVEE IMPROVEMENT EXAMPLES	PURPOSE	BLE AREAS	POSITIVES	NEGATIVES
 F. Placement of Fill on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Filter/Drain System on Landside Slope. Densification of Levee and Foundation Soils Using Vibroreplacment (Stone Columns) or Compaction Grouting.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path, stabilizes concentrated leaks and prevents piping erosion through levee. o Placement of berm accounts for soft foundation. o Densification of levee and foundation soils prevents/limits earthquake-induced liquefaction.	Delta where both on materials and erials exist. nd/or levee	a. Levee structural stability is improved. b. Provides significant improvement in control of seepage problems in levee. c. Densification reduces amount of slumping and cracking which may occur during an earthquake. Filter/drain may prevent piping erosion following an earthquake (and flood events).	a. Requires significant import of mineral soil. b. Placement of fill represents a significant cost. c. Construction of filter/drain represents additional cost. d. Densification represents a major cost. e. Provides no environmental enhancement. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Densification construction may cause levee distress or seepage problems if not carried out carefully. h. Seepage system may need to be modified. i. Seepage and filter/drain system may need to be maintained. j. Infringes on inboard farm land or habitat areas.
 G. Construction of Concrete Wave Wall on Levee Crown	o Provides wave protection during high tides and flood events (Probably only an interim measure).	elta where d is of ern.	a. Provides wave protection. b. Relatively inexpensive. c. Can be constructed relatively quickly.	a. Provides no significant improvement in: - overall freeboard. - structural stability. - seepage control. - piping erosion. - seismic stability. b. Provides no environmental enhancement.
 H. Construction of Sheetpile Wave Wall on Levee Crown	o Provides wave protection during high tides and flood events (Probably only an interim measure).	elta where d is of ern.	a. Provides wave protection. b. Relatively inexpensive. c. Can be constructed relatively quickly.	a. Provides no significant improvement in: - overall freeboard. - structural stability. - seepage control. - piping erosion. - seismic stability. b. Requires limited import of fill. c. Provides no environmental enhancement. d. Installation of sheetpile wall may result in cracking of levee if not carried out with care.

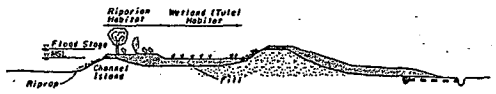
C—070620

TABLE 4-1: EXAMPLES OF LI AND HABITAT IMPROVEMENTS

LEVEE IMPROVEMENT EXAMPLES	PURPOSE	ICABLE AREAS	POSITIVES	NEGATIVES
 I. Maintenance of Vegetation on Existing Levee Slopes	o Provides reasonable on-site growth and regrowth of vegetation while maintaining safety, access, and inspectability of levees.	s in the Delta, but levee stability first evaluated on site basis. vegetation must be with wave systems such to prevent e erosion.	a. Limited waterside vegetation provides some riparian and shaded aquatic habitat. b. Limited waterside vegetation provides some wave protection for levee. c. Grass vegetation provides erosion control for surface runoff. d. Preservation of existing trees provides valuable riparian habitat.	a. If Engineer's guidance not followed and vegetation becomes overgrown, then: - Vegetation limits access for inspection, maintenance, and flood fighting. - Vegetation encourages burrowing rodents. - Downing of trees during storms causes damage to levees due to fallen root balls pulling out chunks of the levee. - Tree roots can also eventually provide a seepage path through levee when they decay. b. Cannot be implemented on Federal levees. c. Because levees require continual maintenance and remediation, some developed habitats need to be covered over with stabilizing berms.
 J. Placement of Fill on Levee Crown and Landside Slope, Together with Landside Berm in Soft Foundation Areas. Creation of Waterside Berm at Mean Sea Level to Create Waterside Wetland Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Waterside Wetland Habitat.	Delta where soft material exists waterside slope is (deep). Cannot here channel s severely	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides valuable Waterside Wetland Habitat (Waterside fill may limit seepage and improve waterside slope stability).	a. Requires major import of mineral soil. b. Placement of landside fill represents a significant cost. c. Placement of waterside fill represents a significant cost. d. Provides only limited increase in seismic stability. e. Limits channel capacity. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Dredging may be needed on waterside. h. Seepage system may need to be modified.
 K. Placement of Fill on Levee Crown and Landside Slope, Together with Landside Berm in Soft Foundation Areas. Creation of Waterside Berm above Mean Sea Level to Create Waterside Riparian Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Waterside Riparian Habitat.	Delta where soft material exists, waterside slope is (deep). Cannot here channel is severely	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides valuable Waterside Riparian Habitat (Waterside fill may limit seepage and improve waterside slope stability).	a. Requires major import of mineral soil. b. Placement of landside fill represents a significant cost. c. Placement of waterside fill represents a significant cost. d. Provides only limited increase in seismic stability. e. Limits channel capacity. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Dredging may be needed on waterside. h. Seepage system may need to be modified.

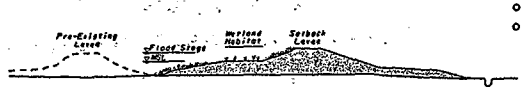
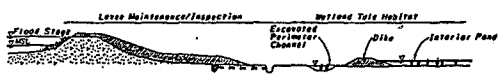
C—070621

TABLE 4-1: EXAMPLES OF LEV AND HABITAT IMPROVEMENTS

LEVEE IMPROVEMENT EXAMPLES	PURPOSE	ICABLE AREAS	POSITIVES	NEGATIVES
 L. Placement of Fill on Levee Crown and Landside Slope. Together with Landside Berm in Soft Foundation Areas. Placement of Fill between Channel Island and Levee to Create Waterside Wetland and Riparian Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Waterside Riparian and Wetland Habitat.	Delta where soft n material exists, channel islands et between island ot too deep. used where apacity is imited.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides valuable Waterside Riparian and Wetland Habitat (Waterside fill may limit seepage and improve waterside slope stability).	a. Requires major import of mineral soil. b. Placement of landside fill represents a significant cost. c. Placement of waterside fill represents a significant cost. d. Provides only limited increase in seismic stability. e. Limits channel capacity. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Dredging may be needed on waterside. h. Seepage system may need to be modified. i. Channel island requires protection.
 M. Placement of Fill on Levee Crown and Landside Slope. Together with Landside Berm in Soft Foundation Areas. Placement of Sand Beach on Waterside Slope to Create Recreation Area.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Recreation Area.	elta where soft material exists, waterside slope steep (deep). used where acity is ited.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides valuable Waterside Recreation Area. (Waterside fill may limit seepage and improve waterside slope stability.)	a. Requires major import of mineral soil. b. Placement of landside fill represents a significant cost. c. Placement of waterside sandy fill represents a significant cost. d. Provides only limited increase in seismic stability. e. Limits channel capacity. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Dredging may be needed on waterside. h. Seepage system may need to be modified. i. Beach area requires maintenance.
 N. Partial Setback of Levee to Create Waterside Riparian Habitat. Placement of Fill on Levee Crown and Landside Slope. Slope. Together with Landside Berm in Soft Foundation Areas.	o Increases freeboard and flood protection. o Increases overall slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Waterside Riparian Habitat.	Delta, but pplicable in areas foundation material	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Lengthens seepage path.	a. Requires significant import of mineral soil. b. Fill placement and cost associated with levee setback greater than simply raising levee crown and adding berm. c. Provides only limited increase in seismic stability. d. Addition of fill likely to result in short-term instability and/or cracking if staged-construction is not used. e. Seepage system may need to be modified. f. Infringes on inboard farm land or habitat areas.

C-070622

TABLE 4-1: EXAMPLES OF I E AND HABITAT IMPROVEMENTS

LEVEE IMPROVEMENT EXAMPLES	PURPOSE	PLICABLE AREAS	POSITIVES	NEGATIVES
 O. Complete Setback of Levee to Improve Channel Capacity, Improve Levee Structural Stability and Provide Waterside Wetland Habitat.	o Increases channel capacity. o Improves levee stability. o Provides Waterside Wetland Habitat.	-eas of Delta, but not in areas where ıick layers of soft -ion material may -eation of new : levees infeasible.	a. Increases channel capacity and improves flood control. b. New levee would be an engineered fill and would not liquefy during seismic events. c. Provides Waterside Wetland Habitat.	a. Requires major import of mineral soil. b. Fill placement and cost associated with levee setback greater than simply raising levee crown and adding berm. c. Foundation liquefaction could still cause failure during future earthquake. d. New levee fill likely to result in short-term instability and/or cracking if staged-construction is not used. This could temporarily make new levee less reliable than existing levee. e. Significantly infringes on inboard farm land or habitat areas.
 P. Placement of Fill on Levee Crown and Landside Slope, Together with Landside Berm in Soft Foundation Areas. Creation of Landside Riparian Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Landside Riparian Habitat.	i of Delta, but y applicable in areas oft foundation material	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides Landside Riparian Habitat. e. Reduces subsidence near levee by not tilling land in habitat area.	a. Requires significant import of mineral soil. b. Represents a significant cost. c. Provides only slight increase in seismic stability. d. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. e. Seepage system may need to be modified. f. Significantly infringes on inboard farm land and requires some land to be taken out of agricultural production.
 Q. Placement of Fill on Levee Crown and Landside Slope, Together with Landside Berm in Soft Foundation Areas. Creation of Inboard Ponds and Waterfilled Perimeter Ditches for Landside Wetland Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Landside Wetland Habitat.	of Delta, but applicable in areas ft foundation material id significant inland :e is occurring.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides Landside Wetland Habitat. e. Reduces subsidence near levee by keeping organic soils saturated.	a. Requires significant import of mineral soil. b. Represents a significant cost. c. Provides only slight increase in seismic stability. d. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. e. Seepage system may need to be modified. f. Significantly infringes on inboard farm land and requires some land to be taken out of agricultural production. g. Inland pond and dike systems require maintenance.

C-070623

MANAGEMENT FRAMEWORK

During the deliberations, a consensus was reached in the TAC that the development of a comprehensive management framework for the Delta was very important. Issues such as funding, environmental and regulatory planning, contingency plans, resource allocation, and organizational structure were considered at least as important as the long-term physical improvement plans which ultimately need to be developed. While the information doesn't exist to complete site specific levee plans, the TAC was able to recommend a management framework which meets these needs. The discussion which follows contains a brief outline summarizing the management framework followed by more detailed analysis of each element (Note — in bold are alternatives that the TAC evaluated and recommend).

Organizational Structure

The Reclamation Board
Department of Water Resources
Delta Protection Commission
Successor to BDOC
New Organization

Cost Sharing Concepts

Extension of SB 34 Program
Negotiated Cost Sharing Formula
Benefit Based Cost Sharing — System Approach
Benefit Based Cost Sharing — Component Approach
Beneficiaries

Resource Allocation

No Action
Maintain and Reclaim All Essential Islands
Sliding Scale
Essential Islands with Varying Levels of Protection
All Islands
Maintain All Islands and Reclaim Essential Islands

Levee Improvement and Maintenance Standards

- Existing Maintenance Level
- Project Federal Standards
- Project Levees to Federal Standards, Non-Project Levees to Bulletin 192-82 or Corps' PL-99
- **Project Levees to Federal Standards, "Essential" Levees to Bulletin 192-82 or Corps' PL-99**

Compliance with Maintenance Standards

- Existing Inspection Programs
- All Levees Inspected
- Funding Tied to Compliance

Contingency Plans

- Continue Existing Disaster Assistance
- **Beneficiary Restoration Fund**

Channel Maintenance and Improvement

- Existing Channel Configuration without Corrective Actions
- **Existing Channel Configuration with Corrective Actions**
- Revise Existing Channel Configuration

Habitat Target Levels

- Target Conditions Existing in the Delta Before 1850
- Target Current Habitat Levels
- **Target Sustainable Habitats**

Recreation Target Levels

- Current Level
- **Current Level With Corrective Actions**
- **Increased Level With Corrective Actions**

Regulatory Process and Permitting

- Programmatic Approach
- Incentive Approach
- Legislative Approach
- Executive Order Approach
- **Combination Approach**

Seismic Problems

No action
Modified Levee Improvements
100-year Earthquake Protection
Maximum Credible Earthquake Protection.

Land Subsidence

No Action
Appropriate Subsidence Control

Delta Database

Clearinghouse and Models
Clearinghouse
Bibliography

ORGANIZATIONAL STRUCTURE

An organization is needed to implement the Delta levees and channel element of the plan for "fixing the Delta." The organization will collect and allocate funds, negotiate agreements, secure environmental and other regulatory approval, develop standards, develop an inspection program, enforce compliance to standards, prioritize work, approve levee and channel workplans, plan for flood fights, develop contingency plans for reclamation of flooded islands, serve as a clearing house/repository of all information pertaining to Delta levees and channels, and perform other necessary tasks for the improvement and maintenance of the Delta levees and channels. The TAC has developed the following alternatives, but no position was developed:

THE RECLAMATION BOARD

Existing State organization, established in 1911; adopts and executes plans of flood control along the Sacramento and San Joaquin Rivers, their tributaries and distributaries. Every plan of reclamation, flood control, drainage, improvement, dredging, or other work that includes any construction or excavation in the bed of, or along, or near the banks or levees of those waters must be approved by the Board. In cooperation with the U.S. Army Corps of Engineers, develops flood control projects in the Central Valley. Funds and staff are provided by the Department of Water Resources.

Positives
- Existing authorities to implement flood control plans in the Delta.
- Existing (although antiquated) authority to assess for construction of flood control projects in the Delta.
- Daily contact with the U.S. Army Corps of Engineers.
- Experience in planning, designing, constructing, operating and maintaining flood control projects.

Negatives
- Needs some additional authority to take on new responsibilities (i.e., channel maintenance, environmental restoration and enhancement).
- Needs additional staff and funding for additional responsibilities.

MANAGEMENT FRAMEWORK

Organizational Structure
- *The Reclamation Board*
- *Department of Water Resources*
- *Delta Protection Commission*
- *Successor to BDOC*
- *New Organization*

Cost Sharing Concepts
- *Extension of SB 34 Program*
- *Negotiated Cost Sharing Formula*
- *Benefit Based Cost Sharing — System Approach*
- *Benefit Based Cost Sharing — Component Approach*
- *Beneficiaries*

Resource Allocation
- *No Action*
- *Maintain and Reclaim All Essential Islands*
- *Sliding Scale*
- *Essential Islands with Varying Levels of Protection*
- *All Islands*
- *Maintain All Islands and Reclaim Essential Islands*

Levee Improvement and Maintenance Standards
- *Existing Maintenance Level*
- *Project Federal Standards*
- *Non-Project Levees to Built. 192-82 or Corps' PL-99*
- *"Essential" Levees to Built. 192-82 or Corps' PL-99*

Compliance with Maintenance Standards
- *Existing Inspection Programs*
- *All Levees Inspected*
- *Funding Tied to Compliance*

Contingency Plans
- *Continue Existing Disaster Assistance*
- *Beneficiary Restoration Fund*

Channel Maintenance and Improvement
- *Existing Channel Config without Corrective Actions*
- *Existing Channel Config with Corrective Actions*
- *Revise Existing Channel Configuration*

Habitat Target Levels
- *Target Conditions Existing in the Delta Before 1850*
- *Target Current Population Levels*
- *Target Sustainable Habitats*

Recreation Target Levels
- *Current Level*
- *Current Level With Corrective Actions*
- *Increased Level With Corrective Actions*

Regulatory Process and Permitting
- *Programmatic Approach*
- *Incentive Approach*
- *Legislative Approach*
- *Executive Order Approach*
- *Combination Approach*

Seismic Problems
- *No action*
- *Modified Levee Improvements*
- *100-year Earthquake Protection*
- *Maximum Credible Earthquake Protection.*

Land Subsidence
- *No Action*
- *Appropriate Subsidence Control*

Delta Database
- *Clearinghouse and Models*
- *Clearinghouse*
- *Bibliography*

DEPARTMENT OF WATER RESOURCES

Existing State organization, established in 1956; manages the water resources of California, in cooperation with other agencies, to benefit the State's people and protect, restore, and enhance the natural and human environments. Major responsibilities are: (1) prepare an update of the California Water Plan; (2) plan, design, construct, operate and maintain the State Water Resources Development System; (3) protect and restore, the Sacramento-San Joaquin Delta; (4) regulate dams, provide flood protection, and assist in emergency management to safeguard life and property; (5) educate the public; and (6) serve local water needs. For the Delta, DWR is controlling salinity and providing water supply for Delta water users, planning long-term solutions for environmental and water use problems facing the Delta, and administering levee maintenance reimbursements and special flood control projects. DWR administers the $120 million SB 34 - Delta Flood Protection Act of 1988. Therefore, is involved in all facets of the Delta levees and channels including cost-sharing, standards, permits, environmental planning, dredging, seismic studies, subsidence control, and design.

Positives
- Fully equipped to manage the Delta.
- Qualified staff and management to address Delta concerns; project management experience in all stages of project development.
- Knowledge of Delta conditions; on-going extensive data collection, research, and analysis.
- Experience in planning, designing, constructing, operating, and maintaining flood control projects in the Central Valley.
- Experience in levee design, maintenance, and inspection in the Delta.
- Experience in flood fighting in the Delta.
- Close working relationship with Federal, State, and local flood control officials.
- Close working relationship and daily contact with regulatory agencies.

Negatives
- Needs additional authority to take on new responsibilities.
- Perceived conflict of interest associated with water transfers.

DELTA PROTECTION COMMISSION

Newly created State organization, which has a sunset date of January 1, 1997; responsible for regional land use and resource management planning in coordination with five counties. Charged with preparation of regional plan to be adopted and carried out by five counties; Commission retains appeal authority over county actions. No authority over special districts or other State agencies. Commission made up of State agency representatives; county supervisors; city representatives; reclamation district representatives.

Positives
- Close working relationship with other State agencies, counties, and reclamation districts
- Regional planning agency; no conflicts with other responsibilities or legal mandates

Negatives
- Needs funding
- Needs to hire experienced staff and management
- Needs additional authority to take on new responsibilities

SUCCESSOR TO BDOC

A joint State-Federal process, with significant emphases on public involvement, tasked to develop long-term solutions for the problems affecting public values in the Bay-Delta estuary. These values are: (1) water quality, (2) fish and wildlife resources, (3) water export system, and (4) levees and channels.

Positives
- Commitment of State and Federal governments to find a Delta solution.
- Draws from the collective knowledge of State and Federal governments and the public.
- Commitment to develop details for implementation
- A single mission; no conflicts with other responsibilities or legal mandates.
- Fresh start; no perceived conflicts of interest.

MANAGEMENT FRAMEWORK

Organizational Structure
- *The Reclamation Board*
- *Department of Water Resources*
- *Delta Protection Commission*
- *Successor to BDOC*
- *New Organizational Structure*

Cost Sharing Concepts
- *Extension of SB 34 Program*
- *Negotiated Cost Sharing Formula*
- *Benefit Based Cost Sharing — System Approach*
- *Benefit Based Cost Sharing — Component Approach*
- *Beneficiaries*

Resource Allocation
- *No Action*
- *Maintain and Reclaim All Essential Islands*
- *Sliding Scale*
- *Essential Islands with Varying Levels of Protection*
- *All Islands*
- *Maintain All Islands and Reclaim Essential Islands*

Levee Improvement and Maintenance Standards
- *Existing Maintenance Level*
- *Project Federal Standards*
- *Non-Project Levees to Built. 192-82 or Corps' PL-99*
- *"Essential" Levees to Built. 192-82 or Corps' PL-99*

Compliance with Maintenance Standards
- *Existing Inspection Programs*
- *All Levees Inspected*
- *Funding Tied to Compliance*

Contingency Plans
- *Continue Existing Disaster Assistance*
- *Beneficiary Restoration Fund*

Channel Maintenance and Improvement
- *Existing Channel Config without Corrective Actions*
- *Existing Channel Config with Corrective Actions*
- *Revise Existing Channel Configuration*

Habitat Target Levels
- *Target Conditions Existing in the Delta Before 1850*
- *Target Current Population Levels*
- *Target Sustainable Habitats*

Recreation Target Levels
- *Current Level*
- *Current Level With Corrective Actions*
- *Increased Level With Corrective Actions*

Regulatory Process and Permitting
- *Programmatic Approach*
- *Incentive Approach*
- *Legislative Approach*
- *Executive Order Approach*
- *Combination Approach*

Seismic Problems
- *No action*
- *Modified Levee Improvements*
- *100-year Earthquake Protection*
- *Maximum Credible Earthquake Protection.*

Land Subsidence
- *No Action*
- *Appropriate Subsidence Control*

Delta Database
- *Clearinghouse and Models*
- *Clearinghouse*
- *Bibliography*

Negatives
- Needs funding
- May need to hire experienced staff.
- May need additional authority to take on new responsibilities.

NEW ORGANIZATION

Establish a new single-purpose organization to improve and maintain a Delta levee and channel system to sustain associated multiple uses.

Positives
- A single mission; no conflicts with other responsibilities or legal mandates.
- Fresh start; no perceived conflict of interest.

Negatives
- Needs to establish organization.
- Needs funding.
- Needs to hire experienced staff and management.
- Public perception; another layer of bureaucracy.
- Need to establish authority

COST SHARING CONCEPTS

Although many Delta Levee and channel issues exist, experience has shown that with sufficient funding many of these obstacles can be overcome. Therefore, a high priority of future efforts should be to establish a reliable long-term funding mechanism for implementing levee and channel improvements.

Levee improvements and maintenance in the Delta, for the most part, are done by local reclamation districts and paid for by local landowners. The Department of Water Resources maintains a relatively minor portion of the levee system; the costs of that effort for certain levees, such as along the Yolo Bypass, are paid by the State General Fund, while others, within the reach of Maintenance Area 9, are assessed to adjacent property owners.

Currently, under the SB 34 program, the State provides financial assistance to RDs maintaining project levees. SB 34 will sunset at the end of 1998. While this assistance is very important for mitigating flood hazards, it is insufficient to address levee and channel improvements and maintenance on a significant long-term basis.

In recognition of the nation-wide benefits of the Delta levee and channel system, a reliable and equitable long-term funding mechanism needs to be established for the improvement and maintenance of the levee system to sustain its associated uses. The TAC developed the following alternatives, but no position was developed:

EXTENSION OF SB 34 PROGRAM

Reimburse RDs for some of the levee improvement and maintenance work. Sources of funds: (1)State of California and (2) RDs.

Positives:
- Ease of implementation; existing DWR program.

Negatives:
- Currently applies to non-project levees only; does not address project levees' needs.
- Does not address channel maintenance needs.
- Many RDs are unable to fund the work.

- State funding has been unstable and inadequate.
- Only some of the beneficiaries carry the financial burden.

MANAGEMENT FRAMEWORK

Organizational Structure
- *The Reclamation Board*
- *Department of Water Resources*
- *Delta Protection Commission*
- *Successor to BDOC*
- *New Organization*

Cost Sharing Concepts
- *Extension of SB 34 Program*
- *Negotiated Cost Sharing Formula*
- *Benefit Based Cost Sharing — System Approach*
- *Benefit Based Cost Sharing — Component Approach*
- *Beneficiaries*

Resource Allocation
- *No Action*
- *Maintain and Reclaim All Essential Islands*
- *Sliding Scale*
- *Essential Islands with Varying Levels of Protection*
- *All Islands*
- *Maintain All Islands and Reclaim Essential Islands*

Levee Improvement and Maintenance Standards
- *Existing Maintenance Level*
- *Project Federal Standards*
- *Non-Project Levees to Bulk. 192-82 or Corps' PL-99*
- *"Essential" Levees to Bulk. 192-82 or Corps' PL-99*

Compliance with Maintenance Standards
- *Existing Inspection Programs*
- *All Levees Inspected*
- *Funding Tied to Compliance*

Contingency Plans
- *Continue Existing Disaster Assistance*
- *Beneficiary Reclamation Fund*

Channel Maintenance and Improvement
- *Existing Channel Config without Corrective Actions*
- *Existing Channel Config with Corrective Actions*
- *Revise Existing Channel Configuration*

Habitat Target Levels
- *Target Conditions Existing in the Delta Before 1850*
- *Target Current Population Levels*
- *Target Sustainable Habitats*

Recreation Target Levels
- *Current Level*
- *Current Level With Corrective Actions*
- *Increased Level With Corrective Actions*

Regulatory Process and Permitting
- *Programmatic Approach*
- *Incentive Approach*
- *Legislative Approach*
- *Executive Order Approach*
- *Combination Approach*

Seismic Problems
- *No action*
- *Modified Levee Improvements*
- *100-year Earthquake Protection*
- *Maximum Credible Earthquake Protection.*

Land Subsidence
- *No Action*
- *Appropriate Subsidence Control*

Delta Database
- *Clearinghouse and Models*
- *Clearinghouse*
- *Bibliography*

NEGOTIATED COST SHARING FORMULA

Negotiate a cost sharing formula for the improvements and maintenance of all Delta channels and levees. Cost sharing partners: (1) government, (2) State of California, (3) local governments—cities, counties, and (4) RDs. The formula should reflect each partner's ability to pay. Potential cost sharing formula:

50% Federal Government
30% State of California
10% Local Governments
10% RDs

Positives:
- Simple method.

Negatives:
- May require lengthy negotiations.
- Partner's ability to pay varies with time; may necessitate renegotiations.
- May not realize full cost-sharing potential of all beneficiaries.

BENEFIT-BASED COST SHARING — SYSTEM APPROACH

Develop a cost sharing formula for the improvements and maintenance of Delta levees and channels. Cost sharing partners: a list of Delta-wide beneficiaries follows below. The formula should be developed based on the estimated benefits to each beneficiary for having a complete system.

Positives:
- Beneficiaries will carry the financial burden.
- Should make more funding available.

Negatives:
- Difficult to quantify some of the benefits.
- Need to develop a uniform, acceptable method to estimate environmental benefits.
- Benefits vary with time; estimates need to be kept current.

Benefit Based Cost Sharing — Component Approach

Develop a cost sharing formula for each component of the Delta levee and channel system for the improvements and maintenance of that component. Cost sharing partners are the component beneficiaries, which may vary by component (e.g. water supply, habitat, utilities, etc.). Each formula should be developed based on the estimated benefits to each beneficiary for having that component.

Positives:
- Beneficiaries will carry the financial burden.
- Only those components of the system will remain where the benefits exceed the costs of having that component.

Negatives:
- Difficult to quantify some of the benefits.
- Need to develop a uniform, acceptable method to estimate environmental benefits.
- Benefits vary with time; estimates need to be kept current.

Beneficiaries

Cities, Towns, and Communities
Antioch, Bethel Island, Brentwood, Byron, Clarksburg, Courtland, Discovery Bay, Freeport, Hood, Isleton, Locke, Oakley, Pittsburg, Rio Vista, Ryde, Sacramento, Stockton, Thornton, Tracy, Vallejo, Walnut Grove, West Sacramento and others.

Environmental and Interest Groups
Audubon Society, Bay Institute of San Francisco, California Waterfowl Association, California Striped Bass Association, Environmental Defense Fund, Pacific Interclub Yacht Association, Mokelumne River Alliance, Peninsula Conservation Center Foundation, Planning and Conservation League, Sacramento River Preservation Trust, Save San Francisco Bay Association, Save the American River Association, California Sport Fishing Alliance, Bay Planning Coalition, Ducks Unlimited, Delta Area Planning Council, Federation of Fly Fishers, Friends of the River, Sierra Club, Stone Lake Environmental Group, Sacramento Valley Institute, The Nature Conservancy, The Trust for Public Lands, United Anglers of California, and others.

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- *Benefit Based Cost Sharing — Component Approach*
- *Beneficiaries*

Resource Allocation
- *No Action*
- *Maintain and Reclaim All Essential Islands*
- *Sliding Scale*
- *Essential Islands with Varying Levels of Protection*
- *All Islands*
- *Maintain All Islands and Reclaim Essential Islands*

Levee Improvement and Maintenance Standards
- *Existing Maintenance Level*
- *Project Federal Standards*
- *Non-Project Levees to Built 192-82 or Corps' PL-99*
- *"Essential" Levees to Built 192-82 or Corps' PL-99*

Compliance with Maintenance Standards
- *Existing Inspection Programs*
- *All Levees Inspected*
- *Funding Tied to Compliance*

Contingency Plans
- *Continue Existing Disaster Assistance*
- *Beneficiary Restoration Fund*

Channel Maintenance and Improvement
- *Existing Channel Config without Corrective Actions*
- *Existing Channel Config with Corrective Actions*
- *Revise Existing Channel Configuration*

Habitat Target Levels
- *Target Conditions Existing in the Delta Before 1850*
- *Target Current Population Levels*
- *Target Sustainable Habitats*

Recreation Target Levels
- *Current Level*
- *Current Level With Corrective Actions*
- *Increased Level With Corrective Actions*

Regulatory Process and Permitting
- *Programmatic Approach*
- *Incentive Approach*
- *Legislative Approach*
- *Executive Order Approach*
- *Combination Approach*

Seismic Problems
- *No action*
- *Modified Levee Improvements*
- *100-year Earthquake Protection*
- *Maximum Credible Earthquake Protection.*

Land Subsidence
- *No Action*
- *Appropriate Subsidence Control*

Delta Database
- *Clearinghouse and Models*
- *Clearinghouse*
- *Bibliography*

Local Governments
96 Delta Reclamation and Maintenance Districts, 5 Counties: Contra Costa, San Joaquin, Sacramento, Solano, Yolo and others.

Private Interests
Home Owners, Business Owners, Canneries, Farmers, Hunting Clubs, Natural Gas Producers, West Delta Industry, Yacht Clubs and others.

Recreation
Anglers, Boaters, Hunters, Marinas, Water Skiers, and others.

Regulatory Agencies
National Marine Fisheries Service, California Department of Conservation, California Department of Fish and Game, Federal Emergency Management Agency, U. S. Environmental Protection Agency, Regional Water Quality Control Board, State Water Resources Control Board, California Water Commission, State Reclamation board, State Lands Commission, U. S. Army Corps of Engineers, U. S. Coast Guard, Public Utilities Commission, U. S. Fish and Wildlife Service, and others.

Responsible State and Federal Officials
California Department of Transportation, Department of Parks and Recreation, Department of Water Resources, Department of Boating and Waterways, U. S. Army Corps of Engineers, U. S. Bureau of Reclamation, and others.

Utilities
Pacific Gas & Electric Company, Pacific Gas Transmission Company, Sacramento-Yolo Port District, Western Area Power Administration, Southern Pacific Company, Stockton Port district, Union Pacific Railroad, Santa Fe Railroad, and others

Water Suppliers/Agencies
Byron-Bethany Irrigation District, Contra Costa Water District, Sate Water Project/Department of Water Resources, Central Valley Project/U. S. Bureau of Reclamation, Contra Costa Water Agency, North Delta Water Agency, South Delta Water Agency, and others.

RESOURCE ALLOCATION

Most Delta levees require continual maintenance in order to maintain stability. Most of the Delta levees will require significant remediation just to assure flood protection. It will become increasingly expensive to maintain and improve all the levees in the Delta. Therefore, a plan or process needs to be developed to encourage effective use of resources. This process becomes more critical as resources are constrained.

In the Delta, resources are generally expended in three areas: levee rehabilitation to achieve a target level of flood protection, levee maintenance to sustain that target level, and reclamation in the case of island flooding. The resource allocation options that follow are not exhaustive, but outline several combinations that vary with the way public funds are committed to levee rehabilitation, maintenance, and reclamation.

The term "essential islands" is used often in the option descriptions, and refers to a possible designation of each island as either "essential" or "non essential". It is assumed that this designation would be made by some joint Delta authority after careful consideration of a variety of factors, including economic, environmental, and other resource values, existing levee conditions, risks, and constraints. It is recognized that all Delta islands have resource values that would be lost if flooded permanently. Note that in some options the term "essential" applies to all resource allocations, while in other options it only applies to reclamation after flooding.

The TAC has developed the following alternatives:

NO ACTION

Continuation of present system. Levees are improved and maintained by local reclamation districts, assisted by State funding as legislated and available. If an island fails, reclamation is the decision of the local reclamation district and/or owners. The cost of reclamation may be subject to reimbursement by the Federal government.

Positives
- Avoid controversial decisions.
- Avoid new capital costs.

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- Beneficiaries

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- All Islands
- Maintain All Islands and Reclaim Essential Islands

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- Current Level With Corrective Actions
- Increased Level With Corrective Actions

Regulatory Process and Permitting
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- Incentive Approach
- Legislative Approach
- Executive Order Approach
- Combination Approach

Seismic Problems
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Land Subsidence
- No Action
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Negatives
- Reactive approach.
- Expensive in the long term.
- Reliability of levee system is unpredictable.
- Less incentive to maintain Federal levees.
- Uncertainty of reclamation.
- Unreclaimed islands will increase the erosion on adjacent levees.

MAINTAIN AND RECLAIM ALL ESSENTIAL ISLANDS

Each island would be designated as "essential" or "non essential". If an island is designated to be "essential", it will be improved and maintained at a target level using public funds, and reclaimed if the levees fail. Levee improvement, maintenance, and reclamation of "non essential" islands would entirely be the decision of the landowners.

Positives
- No public funds would be expended to rehabilitate, maintain, and reclaim the non-essential islands.
- Proactive approach.
- Reduces uncertainty of levee system.
- Essential islands assured of flood control.
- Levee and habitat improvements are not wasted.

Negatives
- Direct impacts to landowners.
- Indirect impacts to third parties.
- Essential or non-essential decision is controversial.
- One target improvement and maintenance level.
- Unreclaimed islands will increase the erosion on adjacent levees.

SLIDING SCALE

All islands would be placed on a priority list for public funding of improvement and maintenance. Available funds would be distributed proportional to their public benefit. The ranking of islands would be reviewed regularly and re-prioritized to reflect current conditions. "Essential" and "non-essential" islands would be designated to determine whether an island would be reclaimed after flooding using public funds.

Positives
- All islands would be included on the priority list.

- Priority list provides an economic check without making an essential island determination.
- Priority list reflects the variability in the resource values of the islands.
- Essential islands assured flood control.
- Save cost of reclaiming "non-essential" islands.
- Appropriate level of flood protection reflecting resource values.

Negatives

- Public funds used to improve and maintain "non-essential" islands would be lost if those islands are flooded permanently.
- Requires continuing effort to reassess current conditions and redevelop priority list.
- Essential/non-essential decision is controversial.
- All islands on priority list may not receive improvement and maintenance funding.
- Unreclaimed islands will increase the erosion on adjacent levees.

ESSENTIAL ISLANDS WITH VARYING LEVELS OF PROTECTION (RECOMMENDED)

Similar to the "essential islands" option, but allowing for varying improvement and maintenance levels for islands designated as "essential." Differing levels of flood protection would be designated for different land uses. "Essential" islands would be reclaimed after levee failures, and islands determined to be "non-essential" would be improved, maintained, and reclaimed at the expense of the landowners.

Positives

- No public funds would be expended to rehabilitate, maintain, and reclaim the non-essential islands.
- Proactive approach.
- Reduces uncertainty of levee system.
- Essential islands assured of flood control.
- Level of flood protection commensurate with resource values.

Negatives

- Essential or non-essential decision is controversial.
- Unreclaimed islands will increase the erosion on adjacent levees.

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- *Combination Approach*

Seismic Problems
- *No action*
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- *Maximum Credible Earthquake Protection.*

Land Subsidence
- *No Action*
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ALL ISLANDS

Each island would be assigned one of several target levels of levee improvement and maintenance. All islands would be reclaimed if flooded.

Positives
- Level of flood protection commensurate with resource values.
- Reduces uncertainty of levee system.
- All islands are included in improvement and maintenance plan.
- All islands are reclaimed if flooded.
- Avoid essential/non essential decision.

Negatives
- High costs of improvement and maintenance.
- High costs of reclamation.
- The target level of improvement and maintenance should be reviewed for islands that flooded and were reclaimed.

MAINTAIN ALL ISLANDS AND RECLAIM ESSENTIAL ISLANDS (RECOMMENDED)

Each island would be assigned one of several target levels of levee improvement and maintenance, but reclamation of non-essential islands would be the decision of the landowners.

Positives
- Level of flood protection commensurate with resource values.
- Reduces uncertainty of levee system.
- All islands are included in improvement and maintenance plan.
- Essential islands assured of flood control.
- Save cost of reclaiming "non-essential" islands

Negatives
- Public funds used to improve and maintain "non-essential" islands would be lost if that island flooded permanently.
- Requires essential/non-essential determination.
- High cost of improvement and maintenance.
- Unreclaimed islands will increase the erosion on adjacent levees.

LEVEE IMPROVEMENT AND MAINTENANCE STANDARDS

Target maintenance and improvement levels for levees should include improvement standards, minimum levee maintenance criteria and an inspection program that would be administered by a management authority. Existing levee standards and maintenance criteria are included in the appendix of this report.

The following target levels for levee maintenance and improvement should compliment the levee improvement design examples, resource allocations, and contingency plans as appropriate.

EXISTING MAINTENANCE LEVEL

Project levees would be maintained to Federal standards. Non project levees would be maintained to various standards (primarily the State's short term Hazard Maintenance Plan standard).

Positives
- Maintaining non-project levees to HMP standard gives districts financial incentive to implement maintenance program.
- Project levee are generally maintained to a high level because of Federal standards.

Negatives
- Inconsistencies in degree of levee maintenance among non-project districts.
- Uncertainty of flood protection.
- Uncertainty of future funding for levee work.

PROJECT FEDERAL STANDARDS

Maintain all levees to project Federal standards.

Positives
- Consistent standards for all levees.
- High maintenance and improvement standard enhances flood protection.

Negatives
- Extremely high improvement costs.
- High environmental mitigation costs.

PROJECT LEVEES TO FEDERAL STANDARDS AND NON-PROJECT LEVEES TO BULLETIN 192-82 OR CORPS' PL-99 DELTA STANDARDS

Maintain project levees to Federal standards and maintain remaining levees to bulletin 192-82 or Corps' PL-99 delta standards.

Positives
- Standards for non-project levees developed by State and Corps may be attainable and feasible.

Negatives
- High Costs to attain State or Corps' non-project standards.
- Possibly high mitigation costs.

PROJECT LEVEES TO FEDERAL STANDARDS, "ESSENTIAL" LEVEES TO BULLETIN 192-82 OR CORPS' PL-99 STANDARDS (RECOMMENDED)

Maintain project levees to Federal standards and only maintain levees designated as "essential" to Bulletin 192-82 or PL 99 standards and remaining levees maintained to HMP.

Non essential levees could also be maintained to higher standards if the levees' purpose brings in more beneficiaries. For example an island not economically feasible for its present use of agriculture could be maintained if its purpose changed to include protecting environmental values.

Positives:
- High standard for essential levees.
- Costs for improvement only directed to levees deemed essential.
- Islands could be maintained at high level if multipurpose uses bring in more beneficiaries.

Negatives:
- High cost of improvement.
- Difficulty in changing island uses to bring in other beneficiaries.
- Many non essential islands could become shallow lakes and increase erosion on adjacent levees.
- Hard to determine Essential/non-Essential from a political standpoint.

COMPLIANCE WITH MAINTENANCE STANDARDS

An inspection program is necessary to ensure compliance with maintenance standards. The levels of inspection and compliance programs should compliment the target level of maintenance as appropriate. The TAC has developed the following alternatives, but no position was developed:

EXISTING INSPECTION PROGRAMS

Continue Federal levee inspections by Reclamation Board. No levee inspection compliance program applies for remaining levees (except those receiving State subventions funding or qualified for Corps PL-99 assistance). Project levees are inspected semi-annually. Penalty for non-compliance includes imposition of a forced maintenance program. Encroachment permits are required for improvements and modifications to project levees.

Positives
- Non-project levees not receiving government subventions remain independent of government oversight.

Negatives:
- Inconsistencies in levee maintenance and inspection unrelated to benefits provided by each levee.

ALL LEVEES INSPECTED

Same as above except all levees, including non-project levees, are inspected for compliance with applicable maintenance standards.

Positives
- Inspections help in detecting problem areas.
- The threat of imposing a maintenance area would be incentive to comply with the maintenance standard on non-project levees.
- Encroachment control would insure engineering and environmental oversight of levee improvements and modifications.

Negatives
- Cost to staff extra inspectors.
- Permit program would add another layer of bureaucracy for most non-project levees.

FUNDING TIED TO COMPLIANCE

Levee rehabilitation financing would be tied to compliance to applicable maintenance and improvement standards.

Positives
- Effect of levee maintenance ratings on rehabilitation financing provides incentive for compliance with maintenance standards.

Negatives:
- Cost to staff extra inspectors.
- Permit program would add another layer of bureaucracy for most non-project levees.

CONTINGENCY PLANS

A major question when considering the long term viability of the Delta is whether reclamation districts will be able to reclaim flooded islands. Currently there are several disaster-related programs which assist districts to reclaim flooded islands. However, cost-sharing, uncertainty, unattainable qualification standards, unreliability and other factors make it unlikely that these programs will be enough to keep the Delta in its present form. Described below are the current alternatives for reclamation of flooded islands as well as suggestions for additional programs. It must be noted that it is not reasonable to think disaster assistance programs can stand alone; they must go hand in hand with maintenance assistance programs to reduce the probability of levee failure.

The TAC has developed the following alternatives:

CONTINUE EXISTING DISASTER ASSISTANCE

- FEMA AND NDAA

Existing disaster assistance program administered by the Federal Emergency Management Agency (FEMA). The program provides up to 75% reimbursement for repair of damages due to a declared national disaster. In order to be considered for assistance the reclamation district must attain and maintain the levee to minimum standards known as the Hazard Mitigation Plan standards. Currently, State declared disasters provide funds through the National Disaster Assistance Act (NDAA). These funds pick-up a portion of local (25%) cost share for FEMA disasters, or provide most of funding for State declared disasters.

Positives - Provides significant portion of cost of reclamation.

Negatives - Funds are not provided in a timely manner and the district must finance work without any reimbursement of interest charges.

- National disaster declaration sometimes occurs well after the event thus hampering real-time decisions.
- Local cost-share could be prohibitive.
- Rigorous and adversarial audit review.
- Uncertainty whether a district qualifies due to ambiguous HMP criteria.
- HMP standards may be financially unattainable for some districts.
- Does not cover all costs associated with flood event.

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- **PL-99**

The Federal government also currently provides assistance via the Corps of Engineers through Public Law 99-84. Restoration, by the Corps of Engineers, is performed on an 80/20 cost share to districts whose levees meet the standards set forth in the program guidelines and are approved by the Corps prior to the flood which must be declared a national disaster. This program also details the hydrologic criteria defining the flood event for which the program will apply.

Positives
- Provides significant portion of cost of reclamation.
- Local cost share can be in the form of services in lieu of money.
- Not a reimbursement program; Corps performs construction.

Negatives
- Achieving levee standards for pre-qualification is economically prohibitive for most districts.
- Criteria defining "flood" constitute a rare event.
- Local cost share could be prohibitive.

- **EMERGENCY LEGISLATION**

In an event causing significant damage for which either no disaster funding is available or cost sharing for disaster assistance is prohibitive, the State legislature may pass legislation authorizing relief funding. This occurred in 1986.

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Positives
- Takes into account local agency's ability to pay.
- May pay costs not covered by other disaster assistance programs.

Negatives
- Extremely uncertain, especially in light of State's current economic situation.
- May not be timely.

BENEFICIARY RESTORATION FUND (RECOMMENDED)

Fund set-up to levy fees to beneficiaries of Delta levees for use in reclamation of flooded islands. Would include cost share by local agency based on ability to pay. Annual premiums may be based on risk. (Local district must maintain levees to certain standards in order to receive reclamation funds).

Positives
- Very certain source of reclamation funds.

Negatives
- Annualized cost of future disasters would be hard to estimate.
- Hard to determine beneficiaries and their fair share.
- Potentially high cost.
- May eliminate some islands which, after flooding, would increase wind-wave erosion problems along levees of adjacent islands.

CHANNEL MAINTENANCE & IMPROVEMENT

A major question when considering the health of the Delta is whether the existing channel configuration should be maintained or changed. The TAC has developed the following alternatives:

EXISTING CHANNEL CONFIGURATION WITHOUT CORRECTIVE ACTIONS

Preserve the existing channel configuration in its present condition and propose no actions to counteract the forces of nature (e.g. sedimentation, erosion, etc.) or other multiple use impacts on the system.

Positives
- Public acceptability.
- Minimal impacts to the environment.
- Navigational corridors maintained.
- No impacts to water rights and users.
- Preserves what is remaining of historical Delta

Negatives
- May not be economically justified.
- Adverse impact on water quality and supply.
- Loss of valuable habitat, particularly on channel island berms.
- Loss of channel hydraulic capacity.
- Potential impacts to navigation.

EXISTING CHANNEL CONFIGURATION WITH CORRECTIVE ACTIONS (RECOMMENDED)

Preserve the existing channel configuration along with enhancing certain valuable features. Examples of those features would include: (1) the protection and development of channel island berms; (2) channel widening or levee setbacks to improve channel conveyance, relieve hydraulic impacts, and enhance environmental values; (3) dredging to relieve hydraulic impacts, improve channel conveyance, reduce flood stages, provide a source of borrow for levee construction and stabilization, development of shallow water habitat, and use as fill for the enhancement of channel island berms; and (4) development of waterside recreational destination spots for use by the public for water skiing, picnicking, fishing and camping.

Positives
- Public acceptability.
- Enhancement to valuable/hard to find habitat.
- Rehabilitation of levees.
- Navigational corridors maintained.
- No impacts to water rights and users.
- Potential reduction in flood stage.
- Sources of borrow material for levee construction.
- Enhancement of aquatic resources.
- Improvement to water quality and supply.
- Development and enhancement of channel island berms.

Negatives
- Short term impacts to the environment.
- Short term impacts on water quality and supply.
- High capital cost.
- Difficulty in regulatory and permitting process.

REVISE EXISTING CHANNEL CONFIGURATION

Revise existing channel configuration in the Delta under a master plan approach. The present, reclaimed configuration of the Delta is not the most efficient model in providing for its multiple uses. Revisions to such a large system with the high environmental values it possesses is a challenging task. Consideration should be given to reconfiguration of portions of the Delta which will result in providing the most flexibility for its multiple use. Reconfiguration would include: (1) cutting existing channels off; (2) grouping islands and tracts together; (3) shallow filling of certain waterways for aquatic habitat; (4) setting back levee to conform to a more efficient hydraulic model; (5) construction of permanent barriers or channel locks; (6) development of off stream storage reservoirs e.g. "Delta Wetlands Project ;" (7) revisions to existing land use; and (8) dredging to relieve hydraulic impacts, reduce flood stages, and provide a source of borrow for levee construction and stabilization

Positives
- Enhancement to valuable/hard to find habitat.
- Development of a master plan.
- Rehabilitation of existing levees and construction of engineered levees.
- Sources of borrow material for levee construction.
- Enhancement of aquatic resources.
- Improvement to water quality and supply.

- Development and enhancement of channel island berms.
- Reduction in miles of levee to maintain.
- Reduction of flood hazards.
- Provide wetland habitat.

Negatives

- Potential irreversible impacts to the environment.
- Requirement for major importation of fill.
- High capital Cost.
- Significant regulatory and permitting process required.
- Further changes historical configuration of the Delta.

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Resource Allocation
- *No Action*
- *Maintain and Reclaim All Essential Islands*
- *Sliding Scale*
- *Essential Islands with Varying Levels of Protection*
- *All Islands*
- *Maintain All Islands and Reclaim Essential Islands*

Levee Improvement and Maintenance Standards
- *Existing Maintenance Level*
- *Project Federal Standards*
- *Non-Project Levees to Built 192-82 or Corps' PL-99*
- *"Essential" Levees to Built 192-82 or Corps' PL-99*

Compliance with Maintenance Standards
- *Existing Inspection Programs*
- *All Levees Inspected*
- *Funding Tied to Compliance*

Contingency Plans
- *Continue Existing Disaster Assistance*
- *Beneficiary Reinvestion Fund*

Channel Maintenance and Improvement
- *Existing Channel Config without Corrective Actions*
- *Existing Channel Config with Corrective Actions*
- *Revise Existing Channel Configuration*

Habitat Target Levels
- *Target Conditions Existing in the Delta Before 1850*
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Recreation Target Levels
- *Current Level*
- *Current Level With Corrective Actions*
- *Increased Level With Corrective Actions*

Regulatory Process and Permitting
- *Programmatic Approach*
- *Incentive Approach*
- *Legislative Approach*
- *Executive Order Approach*
- *Combination Approach*

Seismic Problems
- *No action*
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- *100-year Earthquake Protection*
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Land Subsidence
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- *Appropriate Subsidence Control*

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HABITAT TARGET LEVELS

The objective of this section is to provide a rationale to establish target levels to protect and enhance critical/sensitive terrestrial and aquatic habitats. Goals should be established to direct efforts in fish and wildlife habitat development. Establishment of goals requires a knowledge of what the biological potential of the Delta is. This potential can be determined from the form habitats took before extensive human intervention occurred (before 1850), tempered by the knowledge of the extensive current day limiting factors such as levees, subsidence, introduction of exotic species, water development, and water quality changes, among many factors. The TAC has developed the following alternatives:

TARGET CONDITIONS EXISTING IN THE DELTA BEFORE 1850

Pre-gold rush conditions may be determined from diaries and other accounts of early California

Positives
- This would be the "pure" approach to setting performance levels for biological resources. Populations of threatened and endangered species may be improved

Negatives
- The physical configuration of the Delta has substantially changed. Radical land form modifications at a high price would be necessary to achieve this target
- The effects of exotic species are not accounted for.
- The effects of changes outside of the Delta are not accounted for.

TARGET CURRENT HABITAT LEVELS

Prevent a "net long-term loss of riparian, fisheries, or wildlife habitat"

Positives
- Current inventories of biological resources are available. Mitigation of adverse impacts can be concurrent with physical levee and channel modifications

Negatives
- Some habitats supporting small populations of plants and animals are threatened with extinction. A positive increase over current levels is needed.

TARGET SUSTAINABLE HABITATS (RECOMMENDED)

An inventory of plant and animal habitats and a documentation of their "health" would provide numerical goals

Positives
- This approach would take into account declining habitats. Remedial actions would prevent plants and animals from becoming "threatened or endangered"

Negatives
- An extensive survey would be required to document the status of all the plant and animal habitats in the Delta.
- Extensive and expensive habitat creation and protection would be required to prevent decline in habitat quality.

RECREATION TARGET LEVELS

The Delta provides the public with a diverse assortment of recreation opportunities. The total recreational use has been estimated at 12 million recreation user days per year. Land-use and recreation planning is typically a county responsibility. Each of the five counties has adopted a General Plan; however, there is minimal coordination among the counties, and each county addresses recreation issues differently. There have been no efforts to coordinate recreation with other Delta uses.

The impacts of recreation on levees has been significant. Levee erosion caused by boat wakes may be one of the most significant of those impacts. Recreationists, especially anglers who drive or walk on unprotected levees, often disturb the soil or remove rip-rap and accelerate levee erosion.

In "fixing the Delta," issues related to recreation must be addressed. The following describes some potential alternative target levels.

CURRENT LEVEL

Sustain current level of recreation opportunities by maintaining the existing conditions (i.e., facilities, legal framework, level of law enforcement, funding, etc.) that provide those opportunities.

Positives
- Relatively low public costs.
- Public acceptability.

Negatives
- Problems, such as trespassing; vandalism; littering; polluting of waters; fires; levee erosion; loss of fish, wildlife, and riparian vegetation, will remain.
- Limited public access.

CURRENT LEVEL WITH CORRECTIVE ACTIONS (RECOMMENDED)

Sustain current level of recreation opportunities with redirection of activities and enforcement of laws to minimize negative impacts. Designate waterways for each water-based recreation activity (i.e., speedboating, houseboating, sailing, fishing, jet skiing, water skiing, swimming, kayaking, canoeing, etc.) and

lands for each land- based recreation activity (i.e., hunting, camping, picnicking, birdwatching, nature study, etc.) in a way that is compatible with other Delta-wide benefits.

Positives
- Address problems associated with current and future conditions.
- Enhance harmony/cooperation among beneficiaries.

Negatives
- Cost.
- Some resistance by recreationists and private interests.
- May require new legislation, ordinances, and additional enforcement.

INCREASED LEVEL WITH CORRECTIVE ACTIONS (RECOMMENDED)

Enhance recreation opportunities in a manner compatible with other priorities, such as improvement and maintenance of levees and the environment.

Positives
- Public acceptability.
- Addresses problems associated with levee maintenance and environment.

Negatives
- High capital cost.
- Does not address all the problems associated with current conditions.
- Potential for increasing conflicting uses.

REGULATORY PROCESS AND PERMITTING

Today, virtually all elements of levee and channel improvements and maintenance are impacted by one or more State and/or Federal laws. Compliance with these laws is the project proponents' responsibility. To assure conformity, the project proponents are required to secure permits, consents, agreements, etc. from various regulatory agencies. Satisfying the regulatory agencies' requirements is a very time consuming, expensive, and, at times, impossible task.

Delays in getting the necessary permits could result in postponement of critical remedial actions and, thereby, could increase the potential for emergencies. Therefore, the project proponents must be fully familiar with the regulatory process and plan for the work well in advance.

For the successful implementation of the proposed levee and channel improvements and maintenance, streamlining of the regulatory process is essential. The TAC has developed the following alternatives:

PROGRAMMATIC APPROACH

In the CEQA/NEPA document for "fixing the Delta," include all proposed foreseeable activities needed to:

- improve all Delta levees and channels,
- maintain all Delta levees and channels,
- floodfight,
- restore levees, and
- reclaim islands.

The Federal lead agency should secure all permits, authorizations, agreements, and consents required by Federal laws, rules, and regulations during the planning phase. The State lead agency should secure all permits, authorizations, agreements, and consents required by State laws and local ordinances during the planning phase.

Positives
- CEQA/NEPA process is well known.
- Clear division of responsibilities.
- Promotes cooperation between State Agencies, Federal Agencies, and RD's.
- Assure consistency in decision making.

- Allow timely implementation of plan.
- Reduce implementation cost.
- Reduce regulators' workload.
- Eliminate fragmented, sometimes duplicate, efforts.

Negatives
- Laws may change prior to or during implementation.
- New scientific information could require permit revisions.
- No reasonable time limits.

INCENTIVE APPROACH

Include specific elements in the project that will encourage regulators to furnish timely approval of all activities. These elements could be identified through negotiations between the lead agency and each regulatory agency.

Positives
- Could foster cohesiveness between regulators and project proponents.
- Regulators would become stakeholders.

Negatives
- Increased costs.
- Short-term solution (Once the element is fully implemented, the incentive no longer exists).

LEGISLATIVE APPROACH

Draft and support passage of legislation to set specific reasonable time limits within which any State or Federal organization approving or disapproving a project must act. For instance, currently there is no time limit for the preparation a biological opinion under the State Endangered Species Act which has resulted in some projects being delayed for years. The consequence of not acting within the set time frame would be approval by default. The Permit Streamlining Act requires timely permit issuance by State agencies.

Positives
- Regulators would more likely set priorities.
- Projects will be implemented.

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Negatives
- Increase pressure on regulators.
- Potential for an increased number of unreasonable decisions.
- Would require changing existing laws.

EXECUTIVE ORDER APPROACH

Assign the responsibility of streamlining the permitting to the regulatory agencies. Direct each regulatory agency's director to report on the progress to the Governor's Office.

Positives
- Provide opportunity to regulators to use their creativity.
- Elevate decision making to appropriate level.
- Establish a framework for greater accountability.

Negatives
- Increase pressure on regulators.

COMBINATION APPROACH (RECOMMENDED)

Combination of all above.

SEISMIC PROBLEMS

The management agency should establish target levels of seismic stability for levees in the Delta. These target levels should include slope stability factors of safety and earthquake-induced deformations and should be done on an island by island basis using specific levels of earthquake loading. The criteria should include considerations of strength loss (e.g. liquefaction) and piping failures. A program for implementing these standards should be part of the management plan.

For many levees, meeting target levels of seismic stability will require substantial efforts and resources for remediating the existing levee system. Levees on the western edge of the Delta are at significant risk for future earthquake-induced distress and/or failure. Widespread failure of levees would have devastating results on Delta water quality and other beneficiaries and could result in some islands being permanently inundated.

Alternative target levels of levee seismic stability that the TAC developed include:

NO ACTION

Delta levees would not be explicitly designed/remediated to meet any particular seismic loading. Studies of potential earthquake risk would be performed to help develop contingency plans in the event of earthquake-induced failures.

Positives
- Risk analyses would provide valuable information for developing contingency plans and budgets.
- Risk analyses may provide information as to which portions of the Delta are worthy of preserving indefinitely.
- Having flexible standards for the design or remediation of levees for seismic loading will conserve limited funds.

Negatives
- This alternative does nothing to improve the seismic stability of Delta levees. Levees on the western edge of the Delta are at significant risk for future earthquake-induced distress and/or failure. Widespread failure of levees would

have devastating results on Delta water quality and other beneficiaries. Widespread levee failure would be difficult to repair quickly and could result in some islands being permanently inundated.

MODIFIED LEVEE IMPROVEMENTS (RECOMMENDED)

Studies of potential earthquake risk would be performed to help develop contingency plans in the event of earthquake-induced failures. Critical levees on the western side of the Delta closer to potential earthquake faults (e.g. Sherman Island levees) would receive levee improvements similar to those proposed for flood conditions (e.g. increased freeboard, flatter slopes, berms, filters, etc.) to provide limited protection for low levels of earthquake shaking.

Positives
- Risk analyses would provide valuable information for developing contingency plans and budgets.
- Risk analyses may provide information as to which portions of the Delta are worthy of preserving indefinitely.
- Limited levee improvements such as increased freeboard, flatter slopes, berms, filters, etc... would provide limited earthquake protection for low levels of seismic loading.
- The limited levee improvements outlined would provide substantial static and flood protection.

Negatives
- This alternative is associated with significant costs and allocation of resources.
- This alternative would not prevent failures following moderate to high levels of seismic loading.

100-YEAR EARTHQUAKE PROTECTION

Studies of potential earthquake risk would be performed to help develop contingency plans in the event of earthquake-induced failures. Critical levees in the Delta would be investigated and improved to adequately perform for earthquake events with an average recurrence interval of 100 years. Design criteria would include the effects of earthquake-induced strength losses (e.g. liquefaction), post-earthquake factors of safety might be set

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Recreation Target Levels
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- *Current Level With Corrective Actions*
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Regulatory Process and Permitting
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- *Incentive Approach*
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Seismic Problems
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Land Subsidence
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equal to 1.2, and earthquake-induced deformations may need to be limited to 3 feet. Substantial remediation in the form of vibroreplacement (stone columns), compaction grouting, the addition of significant mineral soil in the form of berms, and the installation of processed filter zones would be needed in many levee reaches. Because most of the potential fault sources in the Delta lie to the west of the Delta, levees in the western portion of the Delta would require more treatment than those in the eastern portion. However current seismic/tectonic studies indicate potential seismic risk from blind thrust faults underlying the Sacramento Valley area.

Positives

- Risk analyses would provide valuable information for developing contingency plans and budgets.
- Risk analyses may provide information as to which portions of the Delta are worthy of preserving indefinitely.
- Major remediation along levee reaches would provide earthquake protection for low to moderate levels of earthquake shaking.
- Providing protection for a 100-year earthquake would give balanced levels of protection as Delta levees are commonly designed to provide 100-year flood protection.
- Major remediation along levee reaches would also provide substantial static and flood protection.

Negatives

- This alternative is associated with substantial costs and allocation of resources. Seismic stabilization of embankments (essentially a seismic retrofitting) is enormously costly and involves extensive field explorations and design effort. Such an effort is usually applied only to very critical facilities such as nuclear power plants and major dams where major loss of life might result. This effort may be uneconomical if applied to Delta levees for 100-year earthquake loading, and the resources used to simply identify which areas require seismic remediation would probably be better spent in improving the levees by simply adding berms.
- This alternative would not prevent failures following earthquakes with loadings higher than those with 100-year recurrence intervals.

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MAXIMUM CREDIBLE EARTHQUAKE PROTECTION

Studies of potential earthquake risk would be performed to help develop contingency plans in the event of earthquake-induced failures. Critical levees in the Delta would be investigated and improved to adequately perform for the maximum earthquake loading considered possible for the Delta for the current set of tectonic conditions. Design criteria would include the effects of earthquake-induced strength losses (e.g. liquefaction), post-earthquake factors of safety might be set equal to 1.2, and earthquake-induced deformations may need to be limited to 3 feet. Substantial remediation in the form of vibroreplacement (stone columns), compaction grouting, the addition of significant mineral soil in the form of berms, and the installation of processed filter zones would be needed in many levee reaches. Because one of the potential earthquake sources is a buried blind thrust fault beneath the center of the Delta, seismic remediation would be required for critical Delta levees throughout the Delta rather than being limited to critical levees along the western edge.

Positives
- Risk analyses would provide valuable information for developing contingency plans and budgets.
- Risk analyses may provide information as to which portions of the Delta are worthy of preserving indefinitely.
- Major remediation along levee reaches would provide earthquake protection for low to moderate levels of earthquake shaking.
- Providing protection for a 100-year earthquake would give balanced levels of protection as Delta levees are commonly designed to provide 100-year flood protection.
- Major remediation along levee reaches would also provide substantial static and flood protection.

Negatives
- This alternative is associated with significant costs and allocation of resources. Seismic stabilization of embankments (essentially a seismic retrofitting) is enormously costly and involves extensive field explorations and design effort. Such an effort is usually applied only to very critical facilities such as nuclear power plants and major dams where major loss

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of life might result. This effort would be uneconomical if applied to Delta levees for maximum credible earthquake loading. The resources used to simply identify which areas require seismic remediation would probably be better spent in improving the levees by simply adding berms.

- Providing protection for a maximum credible earthquake would result in inequitable risk levels because designs would be developed for an extremely rare earthquake, but more common flood events might not be designed for.
- If implemented, seismic remediation for a maximum credible earthquake would substantially reduce the risk of earthquake-induced levee failures. However, this major remediation would not eliminate the risk.

LAND SUBSIDENCE

Subsidence is a significant factor in many of the central and western Delta levee failures, since it has caused many of the islands' interiors to lie substantially below sea level. Subsidence is due primarily to the loss of organic soil such as peat, a soil that contains more than 50 percent organic matter.

Exposing peat to oxygen causes aerobic decomposition, a process whereby microbial organisms convert organic carbon solids to carbon dioxide and other gases. Activities which raise the soil temperature and reduce soil moisture greatly accelerate this process. This reaction occurs within the first few feet of soil and is referred to as shallow subsidence. Recent studies indicate as much as 50 pounds of carbon per acre are being lost to the atmosphere each day. This carbon loss has a measured effect of lowering the land surface approximately 0.05 mm per day.

Subsidence research indicates that shallow flooding and/or placing dredged fill, will greatly reduce the rate of subsidence. Shallow flooding can consist of flooding an entire island or creating a diked shallow flooded wetland along the landside of the levee. Placing dredged fill will have the same result as shallow flooding since the fill effectively drives the peat layer into the groundwater table.

To adress subsidence problems, the TAC has developed the following alternatives:

NO ACTION

Positives - Does not inhibit or regulate current land use practices.

Negatives - Many Delta islands will continue to be plagued by subsidence generated problems and will result in future levee failures and burdensome maintenance costs.

APPROPRIATE SUBSIDENCE CONTROL (RECOMMENDED)

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- *Programmatic Approach*
- *Incentive Approach*
- *Legislative Approach*
- *Executive Order Approach*
- *Combination Approach*

Seismic Problems
- *No action*
- *Modified Levee Improvements*
- *100-year Earthquake Protection*
- *Maximum Credible Earthquake Protection.*

Land Subsidence
- *No Action*
- *Appropriate Subsidence Control*

Delta Database
- *Clearinghouse and Models*
- *Clearinghouse*
- *Bibliography*

Utilizing one or both methods to control subsidence, where appropriate, would reduce the long term levee maintenance and improvement costs.

Positives
- Controls subsidence.
- Creates valuable wetland habitat along the Pacific Flyway.
- Provides for the beneficial re-use of dredged material.

Negatives
- Limits land use and income potential.
- Dredge fill may not be suitable for some agricultural uses.
- Availability of dredged fill is limited and expensive.

DELTA DATABASE

The selected management organization should serve as a clearing house/repository of all available hydrologic, geotechnical, seismo-tectonic, survey, environmental, and cultural resources information pertaining to the Delta. The organization should maintain a data base/library that would be available to individuals and organizations performing work in the Delta. Alternatives that the TAC developed include:

CLEARINGHOUSE AND MODELS (RECOMMENDED)

The organization will create and maintain a library containing all available reports, maps, appropriate models, data, and photographs relating to Delta issues. As a condition of receiving public funding, individual Delta interests will be required to provide copies of geotechnical, environmental, hydrologic, seismic/tectonic, and topographic information developed both in the past and in the future. The information will be available for public use. In addition, the library will arrange for the compilation of data and the development of maps and models showing conditions in the Delta (e.g. geologic, hydrologic, cultural resources maps).

Positives
- Provides an invaluable resource for island owners, engineers, and public agencies working with both specific and general Delta issues.
- Compilation of data and the development of maps and models provides information in usable form for both the general public and technical specialists.

Negatives
- Library facility requires annual expenditure of resources for space and staff.
- Development and updating of information models and maps represent substantial additional costs.
- Requires constant updating of databases as new information becomes available.

MANAGEMENT FRAMEWORK

Organizational Structure
- The Reclamation Board
- Department of Water Resources
- Delta Protection Commission
- Successor to BDOC
- New Organization

Cost Sharing Concepts
- Extension of SB 34 Program
- Negotiated Cost Sharing Formula
- Benefit Based Cost Sharing — System Approach
- Benefit Based Cost Sharing — Component Approach
- Beneficiaries

Resource Allocation
- No Action
- Maintain and Reclaim All Essential Islands
- Sliding Scale
- Essential Islands with Varying Levels of Protection
- All Islands
- Maintain All Islands and Reclaim Essential Islands

Levee Improvement and Maintenance Standards
- Existing Maintenance Level
- Project Federal Standards
- Non-Project Levees to Built. 192-82 or Corps' PL-99
- "Essential" Levees to Built. 192-82 or Corps' PL-99

Compliance with Maintenance Standards
- Existing Inspection Programs
- All Levees Inspected
- Funding Tied to Compliance

Contingency Plans
- Continue Existing Disaster Assistance
- Beneficiary Restoration Fund

Channel Maintenance and Improvement
- Existing Channel Config without Corrective Actions
- Existing Channel Config with Corrective Actions
- Revise Existing Channel Configuration

Habitat Target Levels
- Target Conditions Existing in the Delta Before 1850
- Target Current Population Levels
- Target Sustainable Habitats

Recreation Target Levels
- Current Level
- Current Level With Corrective Actions
- Increased Level With Corrective Actions

Regulatory Process and Permitting
- Programmatic Approach
- Incentive Approach
- Legislative Approach
- Executive Order Approach
- Combination Approach

Seismic Problems
- No action
- Modified Levee Improvements
- 100-year Earthquake Protection
- Maximum Credible Earthquake Protection.

Land Subsidence
- No Action
- Appropriate Subsidence Control

Delta Database
- Clearinghouse and Models
- Clearinghouse
- Bibliography

CLEARINGHOUSE

The organization will create and maintain a library containing all available reports, maps, appropriate existing models (does not include the development of new models), data, geotechnical, environmental, hydrologic, seismic/tectonic, topographic information, and photographs relating to Delta issues. The information will be available for public use.

Positives
- Provides an invaluable resource for island owners, engineers, and public agencies working with both specific and general Delta issues.

Negatives
- Library facility requires annual expenditure of resources for space and staff.
- Requires constant updating of databases as new information becomes available.
- Some information may not be in a usable form for either the general public or technical specialists.

BIBLIOGRAPHY

The agency will create and maintain a bibliography of all available reports, maps, data, and photographs relating to Delta issues. The bibliography will include information as to the location of the available information.

Positives
- Provides a limited resource for island owners, engineers, and public agencies working with both specific and general Delta issues.

Negatives
- Creation and updating bibliography requires minor annual expenditure of resources for staff.
- Some information identified in bibliography may not be available for potential users.
- Some information may not be in a usable form for either the general public or technical specialists.

CONCLUDING STATEMENT & FUTURE RECOMMENDATIONS

The assignment for the Delta Levees and Channels Technical Advisory Committee has been particularly difficult. Levees and channels provide protection or means for developing beneficial features. However, unlike issues such as water transfer, water quality, wildlife, and aquatic habitat, levees and channels are not actually beneficial features in themselves. Accordingly, the identification of the appropriate levee and channel system to be maintained and the improvements required need to follow the identification of what benefits the levees and channels are intended to protect and/or provide.

Once the needs and benefits in different locations in the Delta are identified, then maintenance of the levee and channel system is critical to protecting these needs. Not enough attention is being paid to this reality.

There is often discussion of the desirability of restoring pre-1850 conditions in the Delta which largely consisted of marshlands lying about mean sea level. However, following reclamation and over 100 years of subsidence, Delta lands now consist of levee-enclosed, cultivated land considerably below sea level. If flood protection was to be now abandoned in these areas and nature was allowed to take its course, the levees would fail and the interior islands would be flooded. However, flooded areas would not be shallow wetlands, but would be bodies of water approximately 15 to 20 feet deep. Such conditions would be very different than the pre-1850 conditions often discussed. If it is proposed that portions of the Delta be returned to a shallow wetland environment, then island interiors could be diked and flooded in a controlled fashion. However, continuation of such shallow wetland environments would require significant management and maintenance of the system and the need to maintain the island levee system as a whole.

There is considerable debate over whether the existing Delta levee, island, and channel system can or will be maintained over the long term in its entirety. Because resources are limited, it is necessary that resources be prioritized and that the islands, levees, and channels be assigned different levels of acceptable risk and receive appropriate amounts of resources based on this risk assignment. This is already being done in a limited way in the SB-34 program by providing the eight western islands larger amounts of funds for levee maintenance than the other Delta islands. However, this approach needs to be carried out further and may need to include decisions as to what portions of the Delta should be abandoned or not receive public funds for reclamation after future levee failure. These decisions should be

part of a comprehensive regional plan for the Delta that includes all stake-holders in its development and implementation.

Although many Delta levee and channel issues exist, experience has shown that with sufficient funding many of these obstacles may be overcome. Therefore, a high priority of future efforts should be to establish a reliable long-term funding mechanism for implementing levee and channel improvements.

Subsidence is a significant factor in many of the central and western Delta levee failures, since it has caused many of the islands' interiors to lie substantially below sea level. Efforts to control subsidence can benefit valuable wetland habitat and need to be a significant part of any Delta flood control plan. The costs to improve levees to acceptable levels of flood protection is prohibitive for most Reclamation Districts and requires State assistance. If land management practices are not changed, many Delta levees will continue to be plagued by subsidence related problems and will result in future levee failures and burdensome costs to maintain.

Potential failure of levees, both simple and catastrophic, from future seismic events pose a major concern. The cost to improve levees to preclude such major failures is prohibitive for the Reclamation Districts and the State — substantial assistance from all Federal, State and local Agencies involved would be necessary. Implementation of geotechnical engineering practice in levee repair and restoration will help to reduce potential losses from seismic events.